

# California LCFS CCS Update

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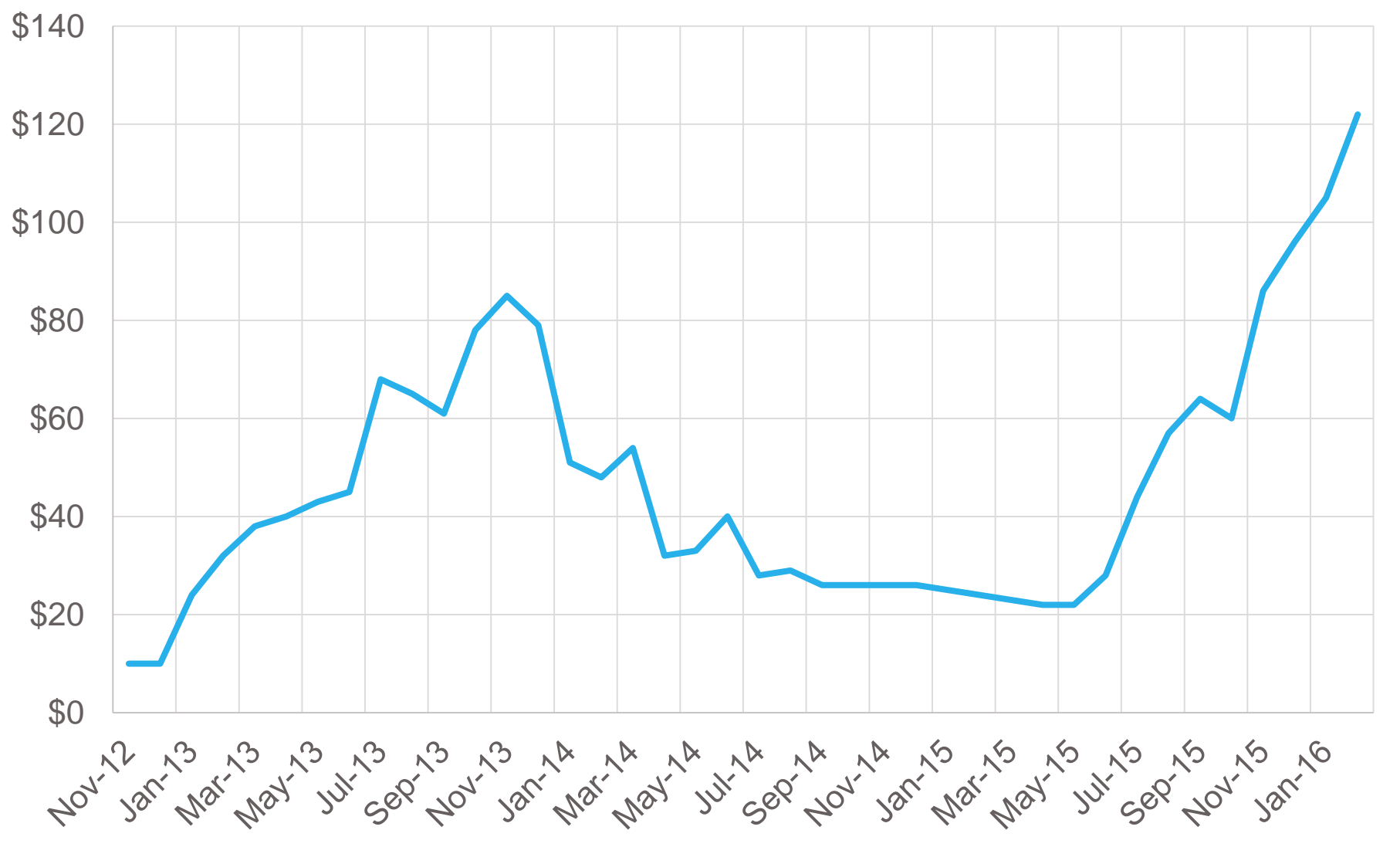


## Introduction

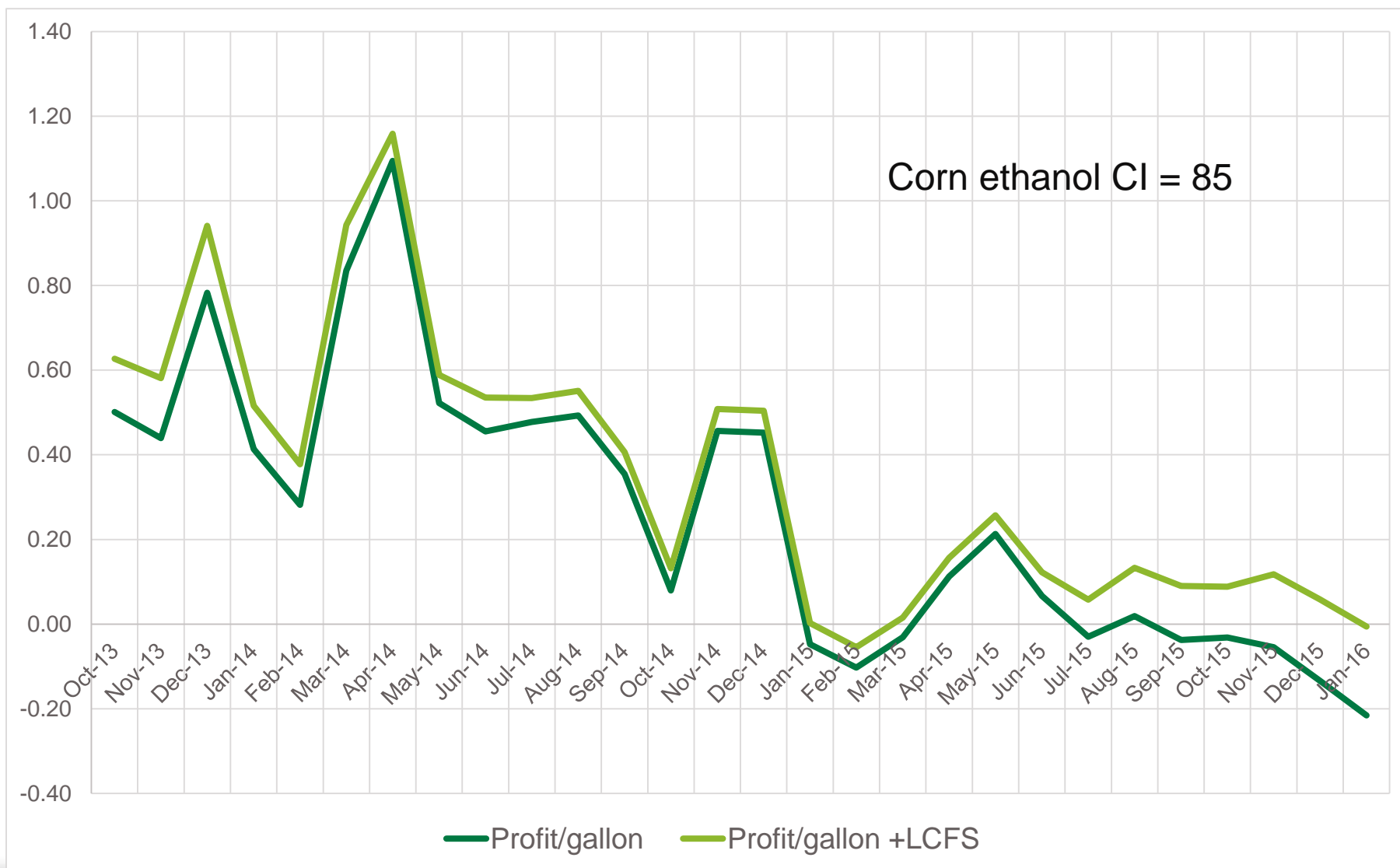
- California LCFS market mandates a 10% reduction in the Carbon Intensity (CI) of transportation fuels by 2020
- To receive credits, ethanol must be below the target CI, which is decreasing through time
- Carbon Capture and Storage of corn ethanol fermentation emissions reduces CI of ethanol (so increases credits)
- California Air Resources Board (CARB) started a rule making process for CCS and CCS credits will be available in 2018



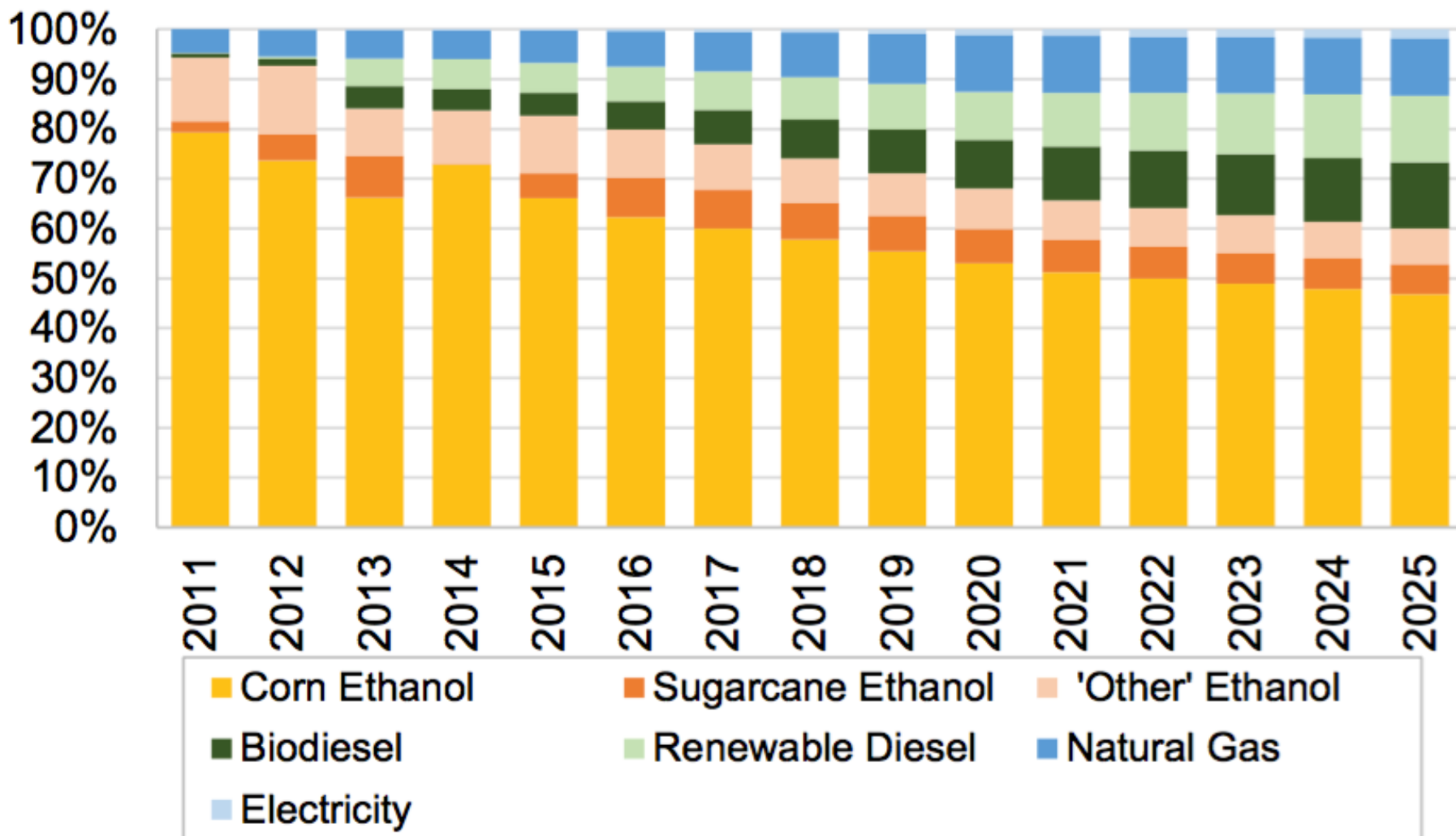
# California LCFS Credit Price History



# Ethanol Net Profit (\$/gallon) with LCFS Credits

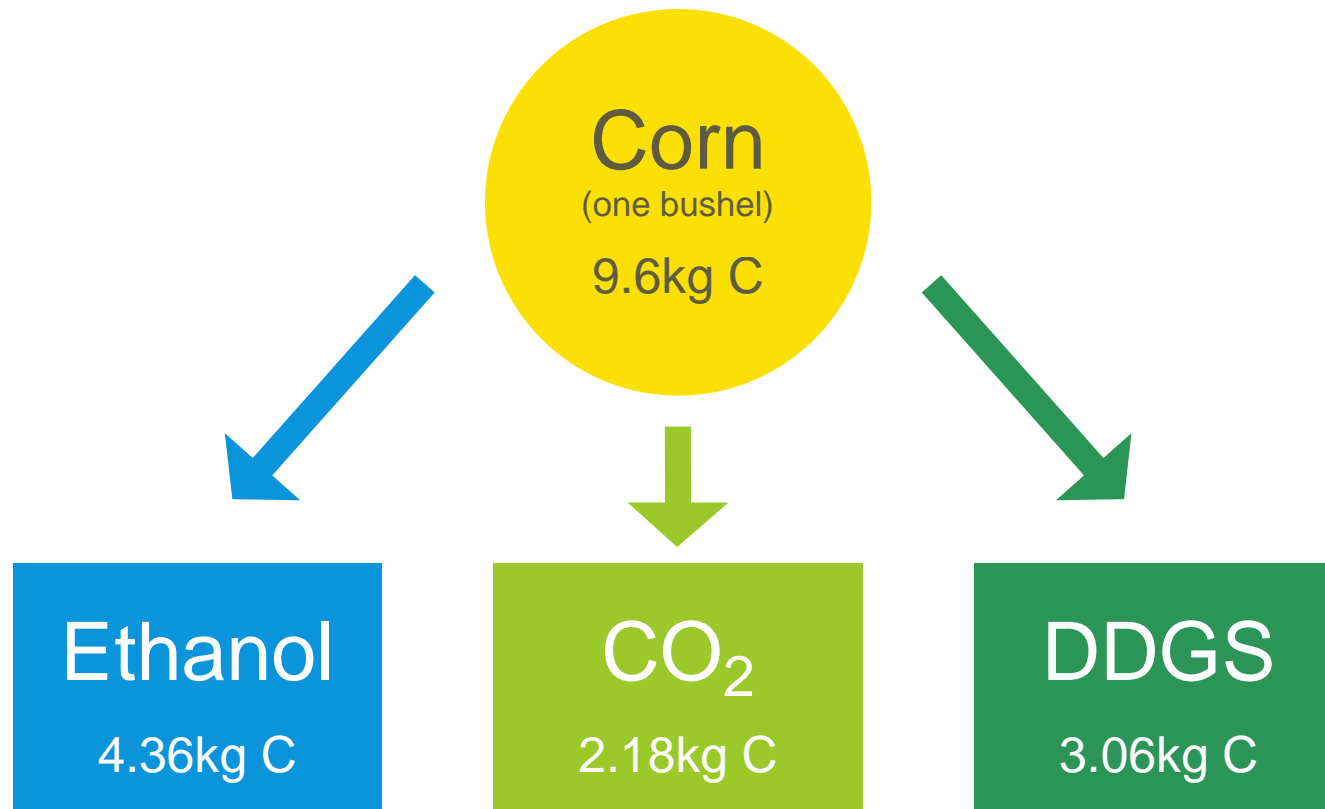


# FORECAST LCFS FUEL VOLUMES BY TYPE



Source: EM<sup>2</sup>

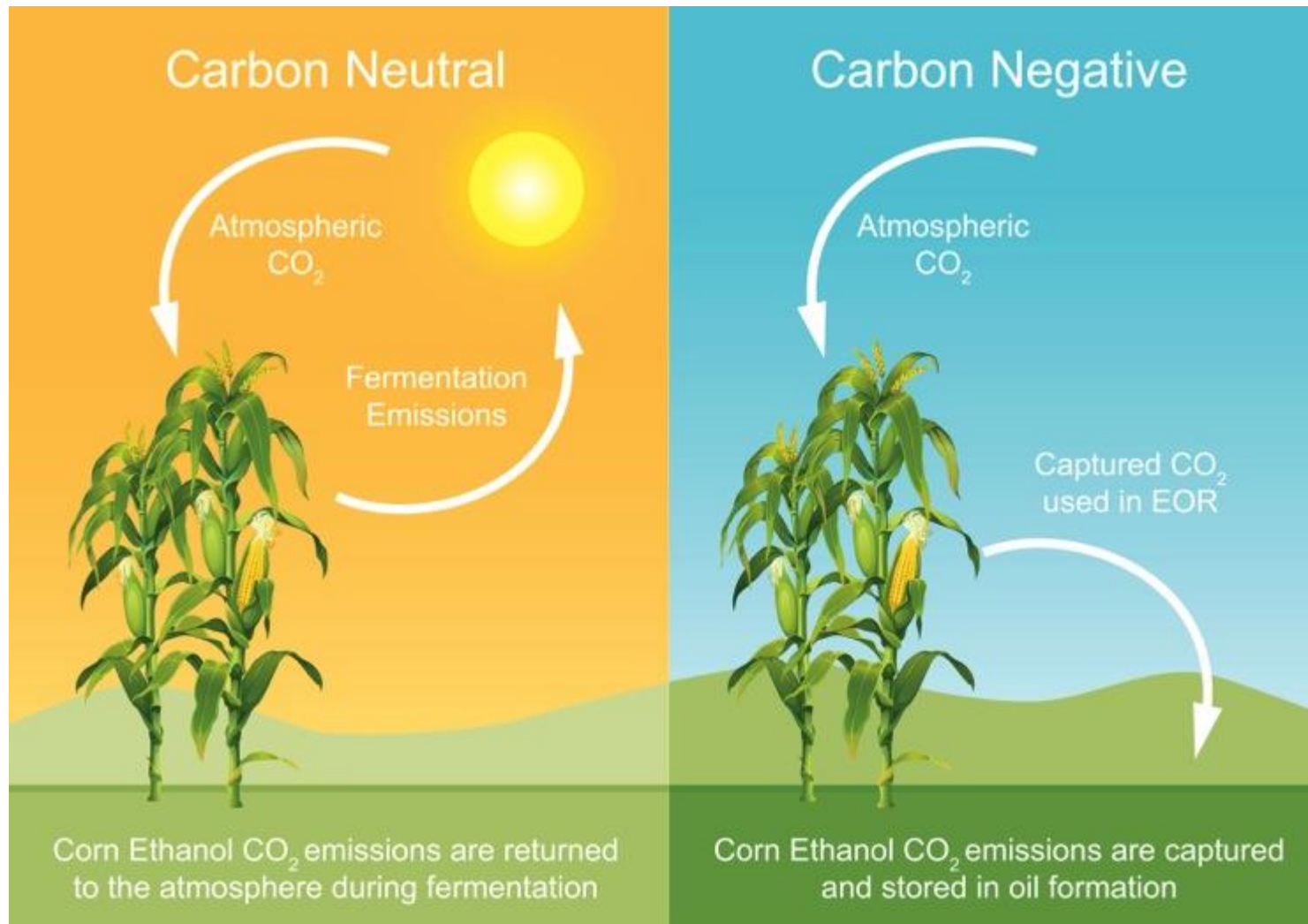
# CORN ETHANOL CO-PRODUCT CARBON CONTENT



Source: Katherine Hornafius (2014)

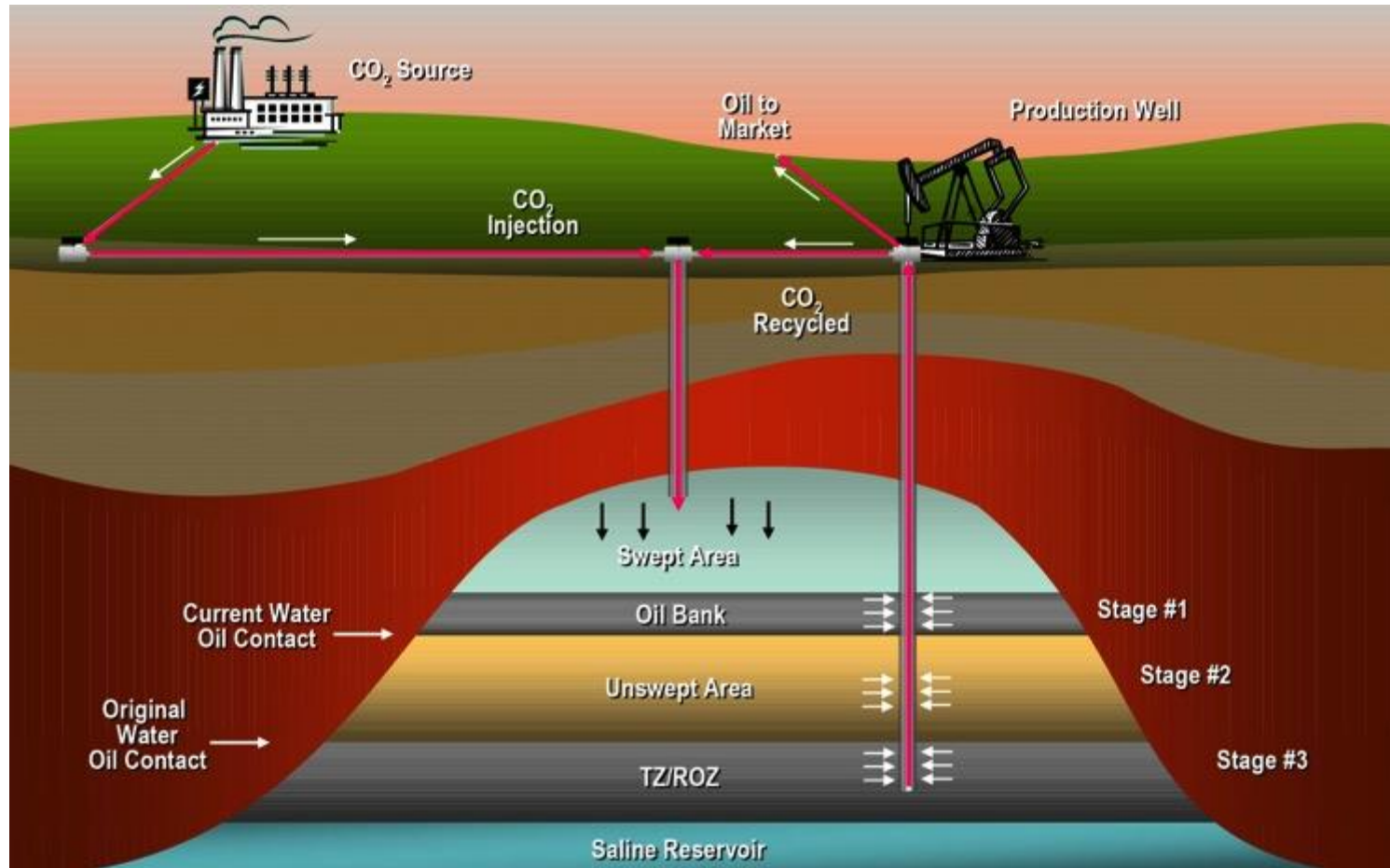


# CORN ETHANOL CO<sub>2</sub> FERMENTATION EMISSIONS PATHWAYS



Source: Hornafius & Hornafius (2015)

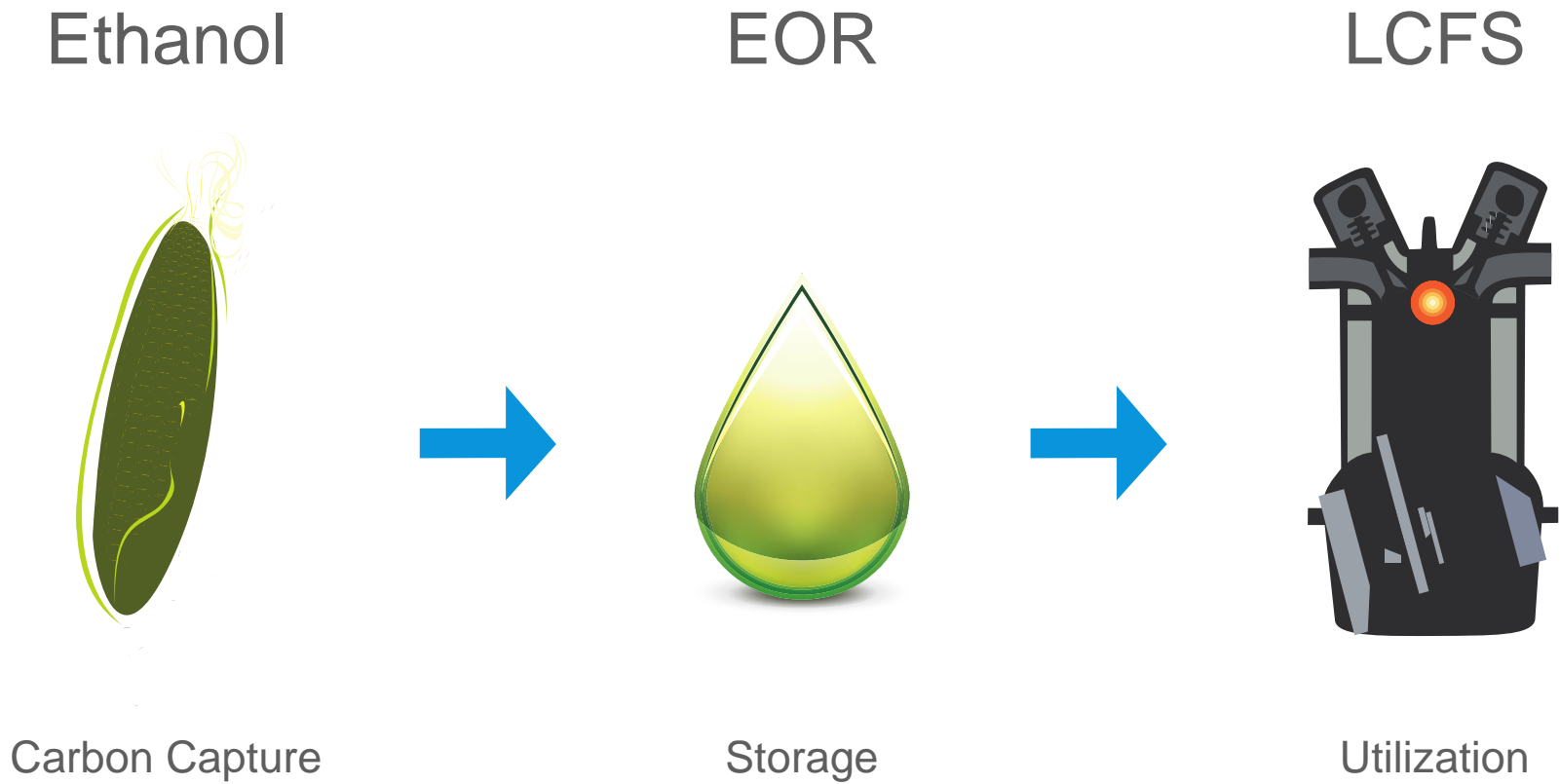
# CARBON DIOXIDE ENHANCED OIL RECOVER (CO<sub>2</sub>-EOR)



Source: Advanced Resources International

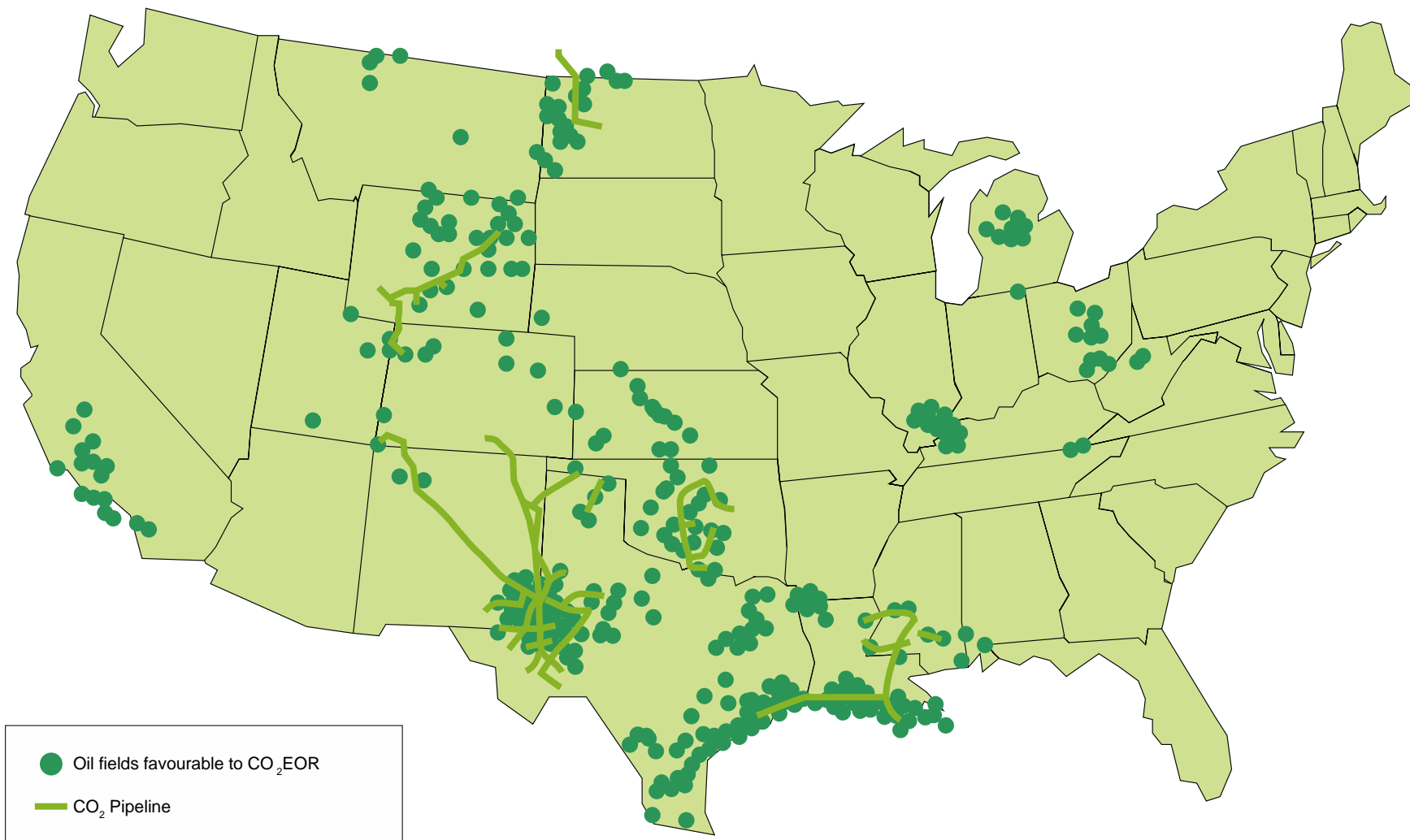


# CARBON VALUE CHAIN

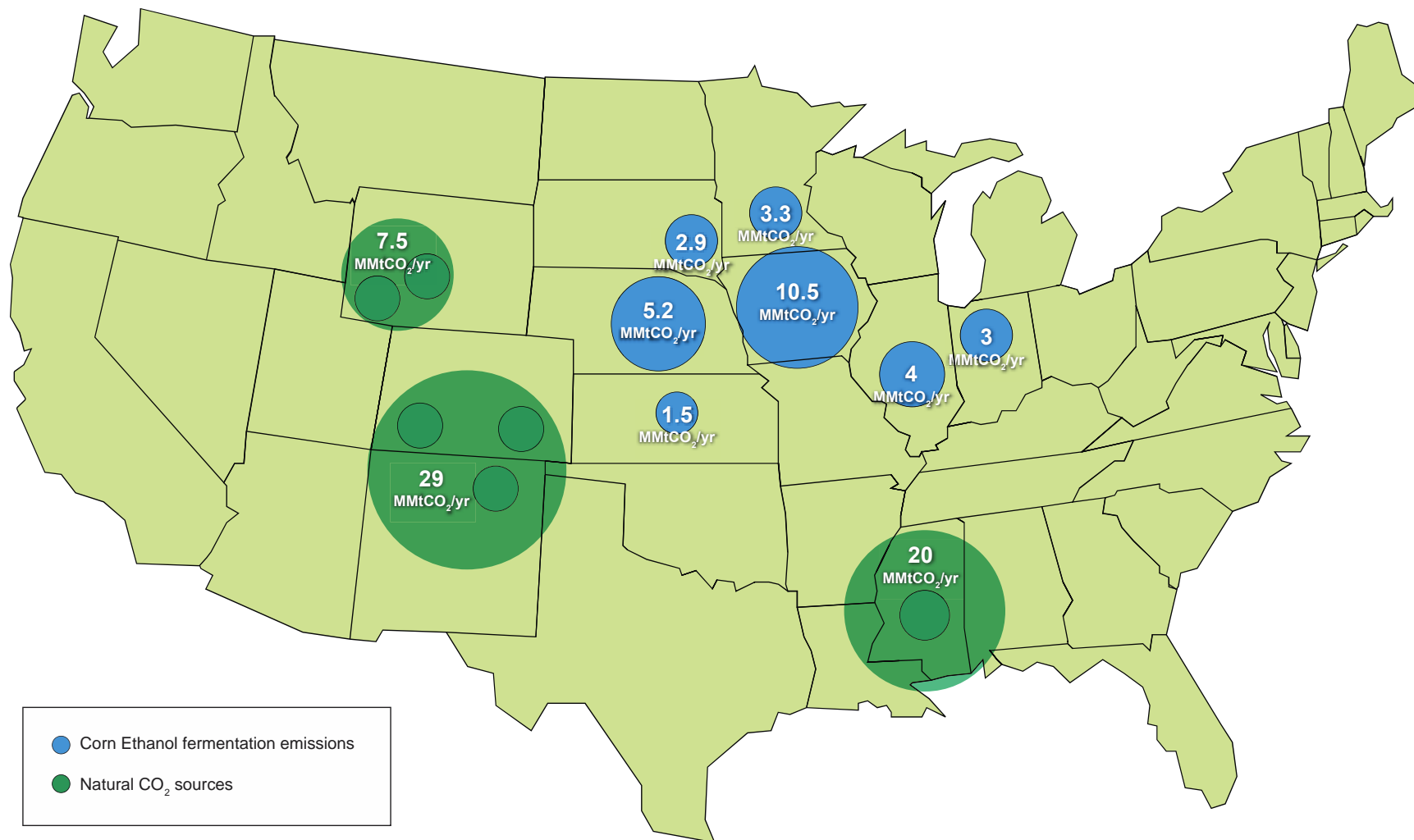


Source: Katherine Hornafius (2014)

# CURRENT CO<sub>2</sub> PIPELINE INFRASTRUCTURE & OIL FIELDS FAVOURABLE TO CO<sub>2</sub>-EOR

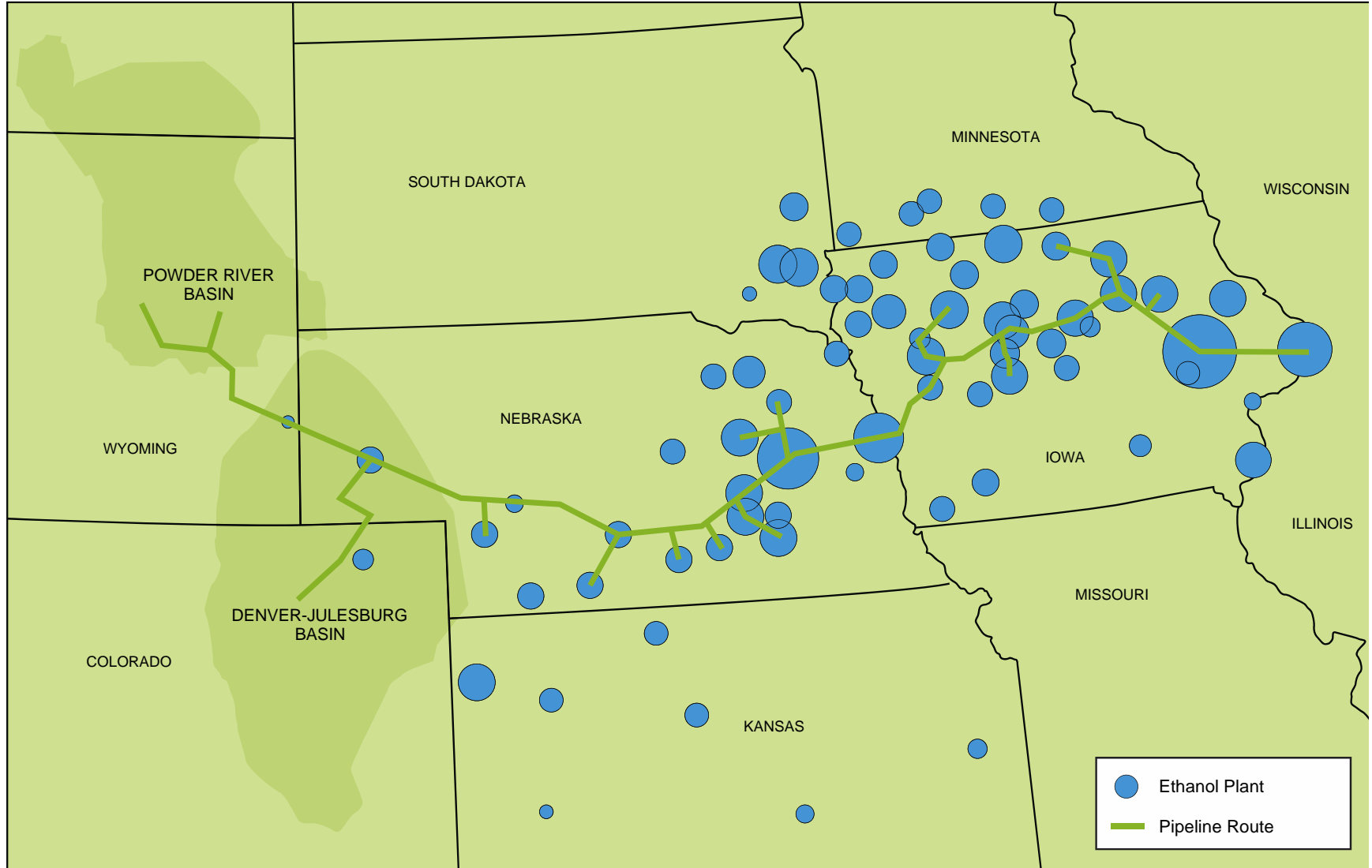


# CO<sub>2</sub> SOURCES FOR CO<sub>2</sub>-EOR



Source: Hornafius & Hornafius, Carbon Negative Oil, IJGGC (2015)

# POSSIBLE CO<sub>2</sub> PIPELINE– Relative Ethanol Plant Capacities



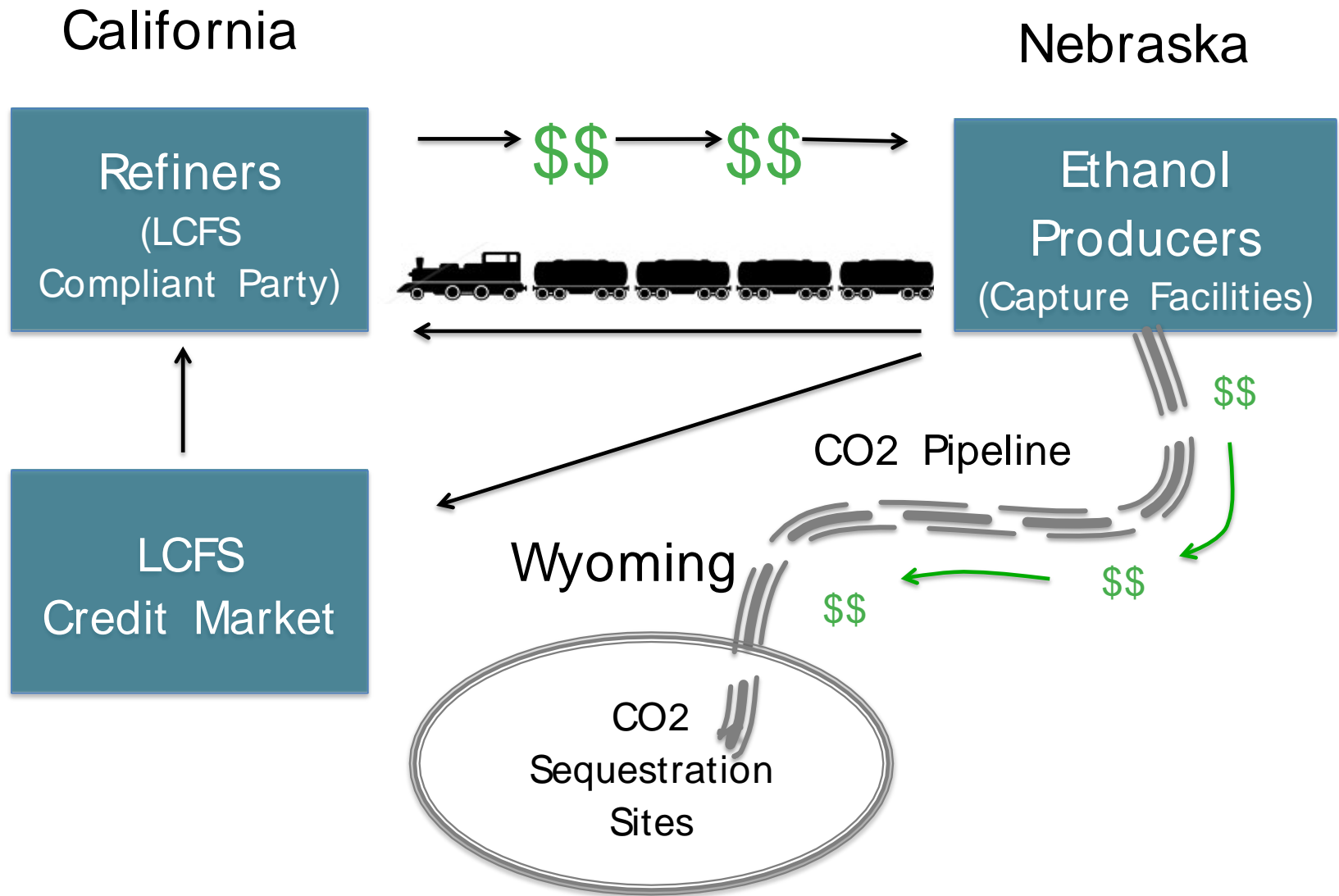
# CO<sub>2</sub> PIPELINE CONSTRUCTION

- \$1+ million/mile
- One year to construct
- 50 year life



Source: Global CCS Institute

# CALIFORNIA LCFS CASH FLOWS FOR CCS

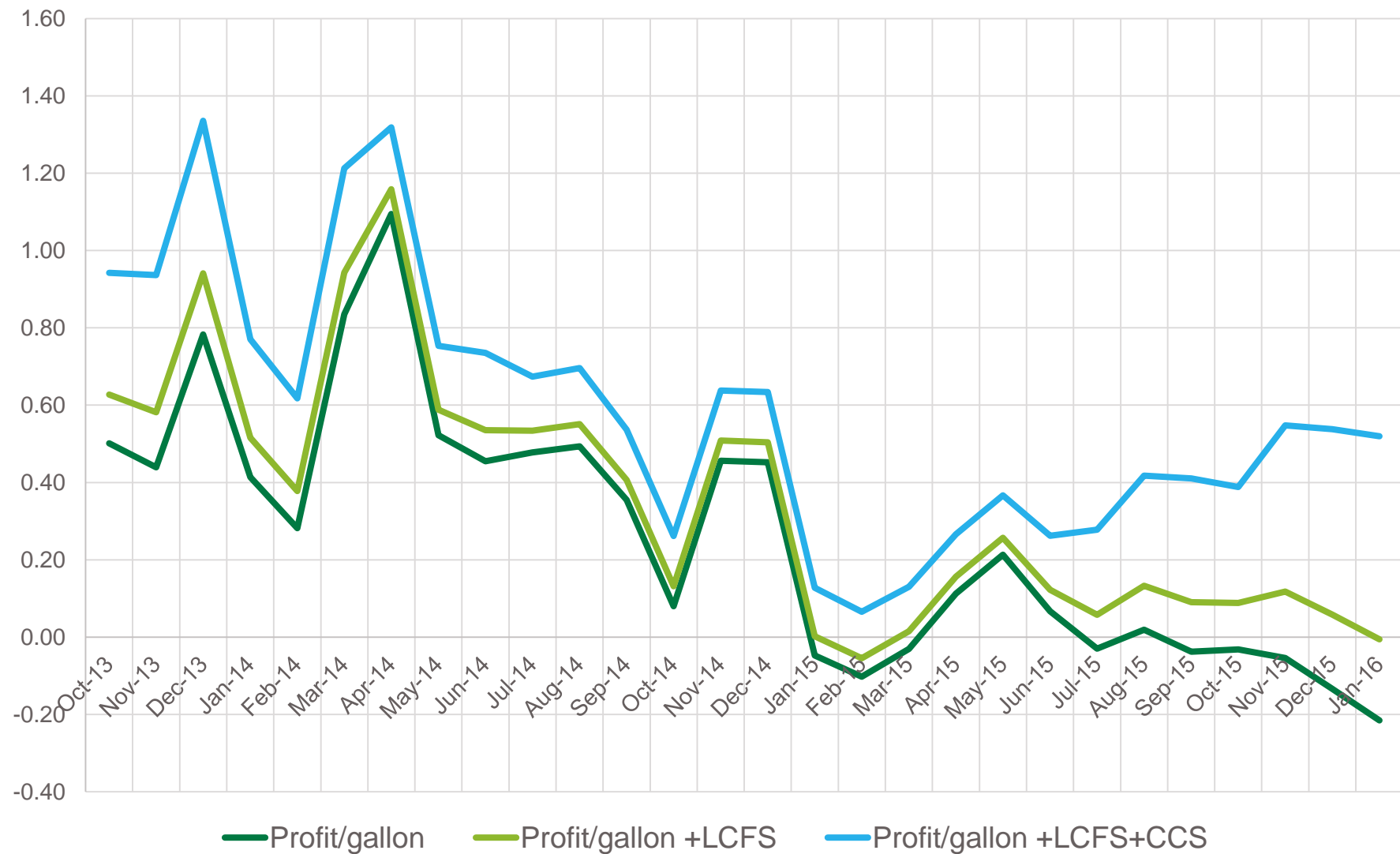




# Ethanol Incremental Economics with LCFS Credits for CCS

- Base Case Assumptions
  - 500 mmcf/day of CO<sub>2</sub> delivered to Wyoming for EOR
  - 2,853 MT/CO<sub>2</sub> per million gallons of ethanol
  - 85% capture
  - \$25 million CAPX for capture facilities for 100 MGA plant
  - Ethanol producer pays to ship CO<sub>2</sub> to Wyoming
  - Ethanol with CCS has CI of 60
  - LCFS Credit Price = \$100/metric tonne
- Base Case Returns
  - 10 year IRR = 32%
  - 10 year NPV @ 10% = \$25 million

# Ethanol Net Profit (\$/gallon) with LCFS and CCS Credits



## Summary

- Carbon Capture and Storage of corn ethanol fermentation emissions reduces CI of ethanol (so increases credits)
- Partnerships with the oil industry will enable corn ethanol to increase the credits available from the LCFS market
- If the CCS rule making by CARB awards the credits to the the capture facility, then the ethanol industry will need to finance the capture and transportation of CO<sub>2</sub>
- Large-scale CCS project is highly profitable at \$100/ton LCFS credit prices

